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(54) IMPROVEMENTS IN OR RELATING TO ELECTRIC BATTERIES

(71) I, JAOB AUERBACH, an Israeli citizen of 18 MacDonald Street, Ramat Gan, Israel, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to electric batteries, more particularly to "tall batteries", i.e. batteries having a high HEIGHT-to-WIDTH ratio (e.g. of 5 to 1), and is particularly concerned with such batteries for "High Power Applications", i.e. batteries involving discharge rates of 30 minutes or less, preferably 20 minutes or less (e.g. 10—20 minutes). As used herein the term "electric batteries" refers to all known types in general but to the lead-acid type in particular.

The build up of a tall lead-acid accumulator is well known to comprise, in an appropriate casing, a multiple number of positive and negative plates, which may be assemblies of tubular elements or may be grids in which the active material is held. Each of these plates comprises main conductors extending from top to bottom of the plate, cross bars extending normal to and between individual conductors, the conductors being usually of greater cross-sectional area than the cross bars. As a consequence, the principal flow of current is in the said main conductors. A conventional construction of a positive plate of tubular main conductors is shown in a schematical, elevational view in Figs. 1 and 1*a* of the accompanying drawings (Fig. 1*a* being a sectional view on line B—B of Fig. 1). As can be seen, a number of tubular elements *a* are fixedly held in parallel relationship between top and bottom bars *b* and b^1, the former being equipped with a lug I. A spine *c* extends longitudinally in the centre of each tube *a*.

The power output efficiency of such conventional tall lead-acid cells is severely reduced when discharged at heavy rates e.g. 20 minutes or less. The electrical resistance of the plates plays an important role in reducing the efficiency of the battery due to the I^2R losses in the conducting vertical grid bars or in the spines of the tubular plate resulting in heat, and consequently by non-uniform electrochemical utilization of the active material.

It is desirable to minimize or overcome the above-mentioned disadvantage. By means of this invention a considerable reduction in the electrical resistance of the plates of a tall battery may be achieved with a view to providing a great improvement in high power applications of the battery. The construction according to the invention is considered applicable to nearly all types of plates e.g. tubular, flat pasted thick or thin with cast, stamped or expanded grids, in particular to plates of great height and of narrow width.

According to this invention there is provided a cell for an electrical battery, the cell having two groups of plates of opposite polarity disposed in spaced vertical planes, characterised in that each plate comprises a plurality of horizontally extending conductors, and in that each plate of one group is connected at a plurality of vertically spaced locations to a single current conductor common to all the plates of that group, the common current conductor extending substatially vertically adjacent aligned ends of the horizontally extending conductors of that group's plates.

Preferably the or each common current conductor comprises a plurality of transversely extending elements the end portions of which correspond to said locations.

By way of example, embodiments of this invention will now be described with reference to Figs. 2 to 7 and 7*a* of the accompanying drawings. In the drawings:

Fig. 2 is a schematical, elevational view of a tubular positive plate according to the present invention (drawn in the same manner as Fig. 1, so as to show the contradistinctive features of the new plate);

Fig. 3 is a perspective partly cut-away view of a cell according to the present invention, Fig. 3*a* being a sectional view thereof on the line A—A;

Fig. 4 is an elevational view of a plate assembly incorporated in the cell of Fig. 3;

Figs. 5 and 6 illustrate a preferred form of

preparing improved tubular pockets for the plate shown in Fig. 4; and

Figs. 7 and 7*a* show a preferred form of a ribbed battery separator for use with a plate having tubular conductors.

As can be seen in Figs. 2 and 3, plates indicated as a whole by the numeral 1, extend each in a vertical plane. In the example shown in Fig. 2, the plates are composed of tubes 2, each having its spine 3. In contradistinction to the conventional vertical build up (Fig. 1), the individual tubes 2 extend horizontally and are all held between upstanding conducting bars 4 and 4*a*. The (positive) conducting bar 4 has a number of lugs or terminals I. Similarly, the (negative) conducting bar has such lugs I. An assembly of interdigitating positive and negative plates is formed as shown in Fig. 3*a* and flat bars 5, which are integral with or are conductively connected to laterally extending cross bars 6, are provided at the sides of the plate assembly. The bars 5 serve as main current conductors and are connected to the lugs I via the cross bars 6, thus establishing a connection with each plate at several, vertically-spaced, levels.

It will be seen that the current through the active material of the plates is essentially distributed by mean of relatively short, horizontal bars or spines of suitable cross-section. All bars or spines are of equal length and therefore of equal electrical resistance.

Most surprisingly, at high discharge rates the efficiency of tubular plates possessing—according to the embodiment of this invention just described—horizontal tubes assembled in a vertical plane, will be enhanced by the hydrodynamic turbulence of the ions and/or electrons caused during the discharge.

Pre-assembled plate group units as described above with reference to Figs. 2, 3 and 3*a*, can have any desired practical height (e.g. 800 to 1600 mm) and occupy a relatively small floor space (e.g. 256 to 1024 cm^2) to form cells of high conductivity and larger capacities than hitherto. Obviously, each plate can be assembled of several plate sections which might be advisable or dictated by technological and practical considerations.

The electrical advantages of embodiments of this invention over the conventional design can be stated approximately as follows: given a plate having a vertical extension L and a horizontal extension d, its electrical resistance will be proportional to L/d in the conventional arrangement (Fig. 1), and to d/L according to this invention (Fig. 2). Hence the relative resistance of a plate according to this invention (Fig. 2), having a suitable number of lugs (I), will be $(L/d)^2$ times lower than that shown in Fig. 1 of equal outside dimensions, e.g. in the case of L=100 cm and d=20 cm the resulting resistance according to this invention will be lowered by a factor of 25.

It will therefore be apparent that, compared to a similar size cell of conventional design, a tall lead-acid cell built in accordance with the present invention, being discharged at high rates to a predetermined final voltage, will be likely to have a higher average voltage, and therefore it will be likely to supply more electrical energy. Furthermore, it will be likely to generate less heat. While the cell shown in Fig. 3 illustrates a lead-acid plate group equipped with tubular type positive plates and flat, pasted type negative plates, it would be within the scope of the invention to apply a similar form of construction to other types of plates, as well as to other types of cells. Thus, pasted grid plates would be arranged in vertical planes, with their principal conductors directed horizontally.

Suitably corrugated separators (of known design), with the "crests" and "troughs" of their undulations sequentially disposed in a vertical plane, will produce a similar hydrodynamic turbulence as described above.

The vertical conducting bars (5) may be extended upwardly to form the cell terminals. They can also be utilized as heat exchangers. The vertical bars may be tapering in downward direction, so as to ensure equal current densities per cross-sectional unit at all connecting points throughout a cell.

Also, the horizontal conducting grid bars, or the spines of tubular elements may be of decreasing cross-sectional area in the direction receding from the current collecting point.

Advantageously the said bars 5 may have at their sides at one, or at several points, inwardly extending noses 7 which support the ends of non-conducting rods 8 from which the tubular plate assembly is suspended (Fig. 4). In this manner the whole weight of the assembly no longer rests on the lower tubular elements 2 alone and deformation thereof or buckling of the assembly as a whole in prevented. Conveniently several rods 8 may be inserted at suitable intervals in empty tubes 2 replacing there the normal spine 3 and the active material.

The manufacture of tubes, and of tubular pockets, as used in the conventional design (Fig. 1) is known.

Figs. 5 and 6 illustrate an improved version of tubular pockets which might preferably be used in connection with the present invention. For this improved version the two sheets 10 which are normally used for the manufacture of such tubular pockets are modified in that they are reinforced by special threads 11 of electrically non-conductive, acid-resistant, strong material. These threads 11 may be united with the sheets 10 in different ways: they may be stitched or pasted thereto; they may be fused thereto by application of heat

or may be glued thereto by means of an appropriate adhesive.

The sewing together of the reinforced sheets, the forming of the pockets, and the final curing are all done in accordance with known procedures.

In the finished plate these reinforcing threads 11 will be essentially perpendicular to the direction of the tubes, i.e. they will be horizontal in a conventional type of tubular plate (Fig. 1) and vertical in a tubular plate according to this invention (Fig. 2).

Fig. 7 illustrates an improved version of a ribbed battery separator which might preferably be used in connection with the present invention.

The vertical ribs 20 of the separator 21 have notches 22 of shallow depth, spaced at a pitch similar to that of the horizontal tubes, or pockets. In the assembled cell the said tubes will fit into these notches over the whole plate surface, thus the separator 21, in addition to its normal function, will also be utilized to act against tube distortion.

WHAT I CLAIM IS:—

1. An electric battery cell having two groups of plates of opposite polarity disposed in spaced vertical planes, characterised in that each plate comprises a plurality of horizontally extending conductors, and in that each plate of one group is connected at a plurality of vertically spaced locations to a single current conductor common to all the plates of that group, the common current conductor extending substantially vertically adjacent aligned ends of the horizontally extending conductors of that group's plates.

2. An electric battery cell as claimed in claim 1, characterized in that the or each common current conductor comprises a plurality of transversely extending elements the end portions of which correspond to said locations.

3. An electric battery cell as claimed in claim 1 or claim 2, characterised in that the said horizontally extending conductors of one or each plate are tubular elements of annular or other cross-section.

4. An electrical battery cell as claimed in claim 3, characterised in that the spines of the tubular elements are of decreasing cross-sectional area in directions receding from the said locations.

5. An electric battery cell as claimed in Claim 3 or Claim 4, characterised in that the tubular elements are disposed between two vertical bars, one such bar having laterally extending terminal lugs at said vertically spaced locations.

6. An electric battery cell according to any one of the preceding claims, characterised in that the said horizontally extending conductors of one or each plate are held in or provided by pockets formed of sheets sewn together and reinforced by one or more electrically non-conductive threads or filaments applied to the sheets.

7. An electric battery cell according to claim 6 when dependent from any one of claims 3 to 5 characterised in that the pockets are tubular, the said thread(s) or filament(s) extending perpendicularly to the axes of the tubular pockets.

8. An electrical battery cell as claimed in any one of claims 3 to 5, or claim 7, characterised by a separator between adjacent plates, the separator being provided with vertically extending ribs having notches therein adapted to accommodate the horizontally extending tubular elements.

9. An electric battery cell as claimed in claim 1 or claim 2 and of the pasted grid type, characterised in that the conducting grid bars constituting said horizontally extending conductors are of decreasing cross-sectional area in directions receding from the said locations.

10. An electric battery cell as claimed in any one of the preceding claims, characterised in that plates of the same polarity are interconnected by cross bars.

11. An electric battery cell as claimed in any one of the preceding claims, characterised in that the common current conductors extending substantially vertically project upwardly beyond the plates to form the cell terminals, the upwardly projecting portion of one or each such common current conductor providing a heat exchange means.

12. An electric battery cell as claimed in any one of the preceding claims, characterised in that the common current conductors extending substantially vertically are of downwardly tapering shape in a manner tending to equalise current densities at the said vertically spaced locations.

13. An electric battery cell as claimed in any preceding claim, characterised in that the common current conductors extending substantially vertically have inwardly extending noses carrying one or more electrically non-conducting rods from which the plates are suspended.

14. An electric battery cell, substantially as hereinbefore described and/or as illustrated in Figs. 2 to 7 of the annexed drawings.

15. An electric battery comprising a plurality of cells each according to any one of claims 1 to 14.

For the Applicant,
E. EDER, B.Sc., C.P.A.,
Chartered Patent Agent,
Lonsdale Chambers,
27 Chancery Lane,
London WC2A 1NF.

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Sheet 1

FIG. 1

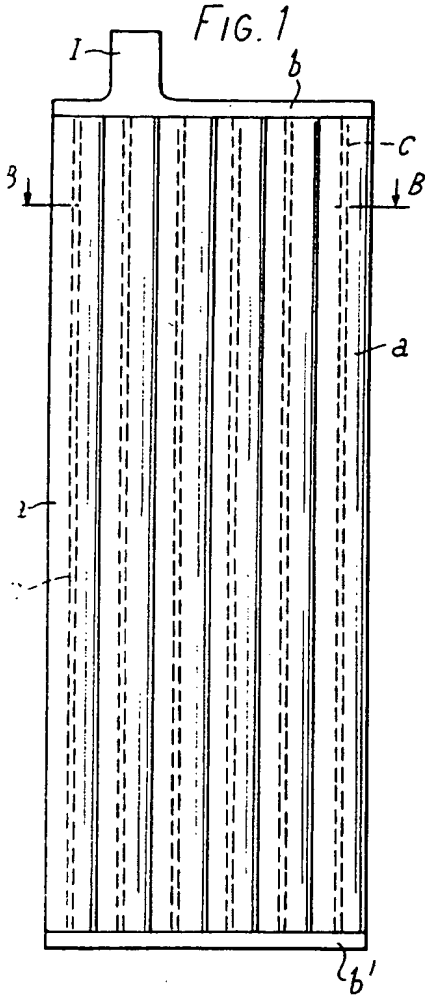

FIG. 2

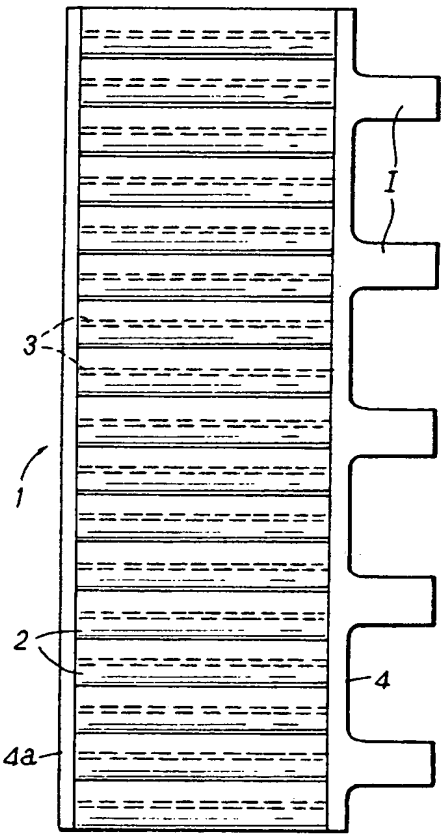

FIG. 1a

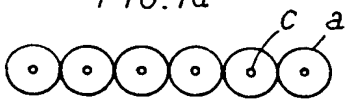

FIG. 3a

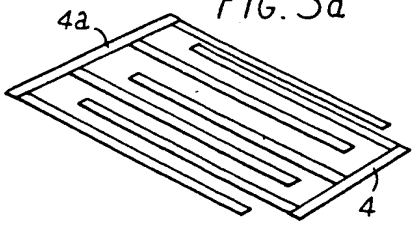

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FIG. 3

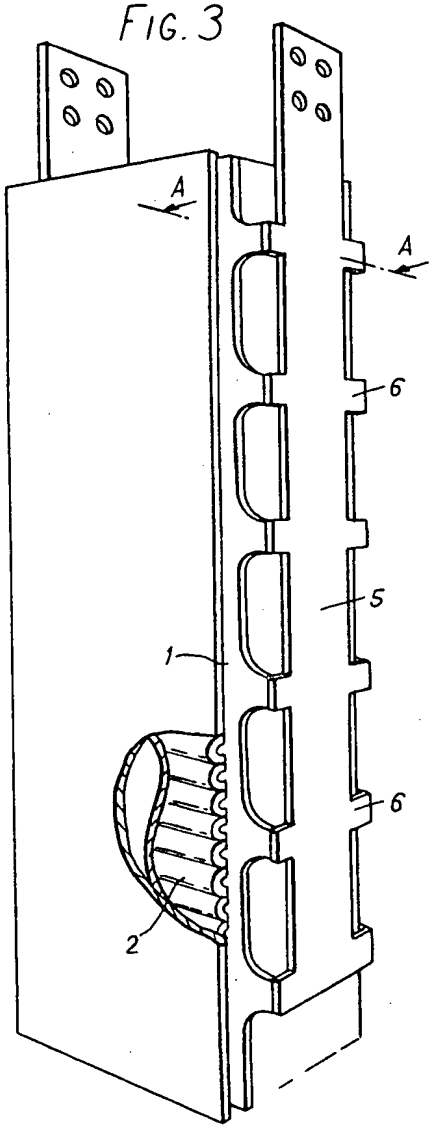
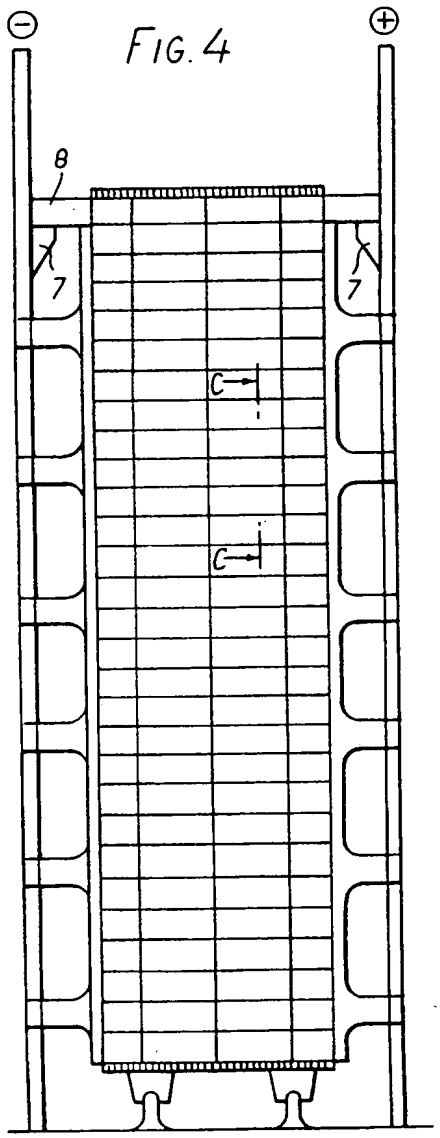


FIG. 4



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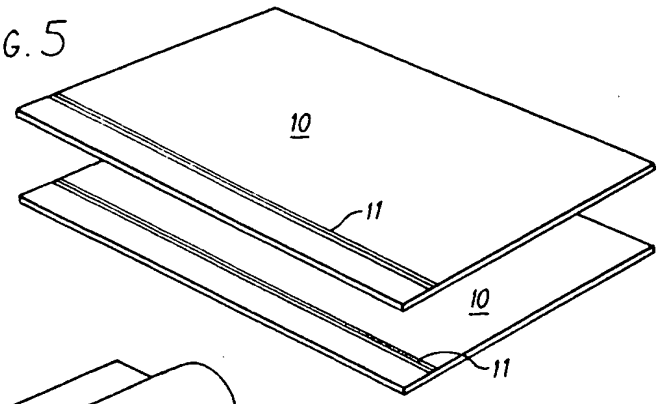
Sheet 3

FIG. 5



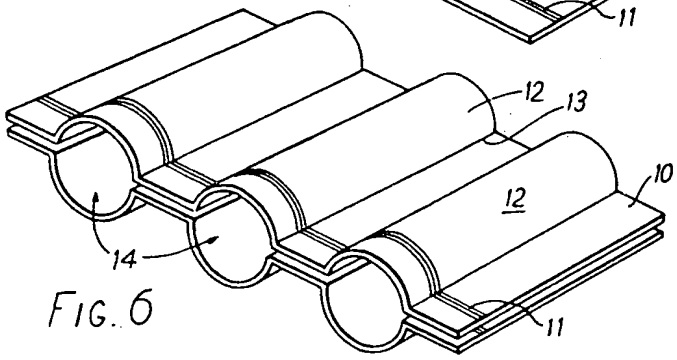


FIG. 6

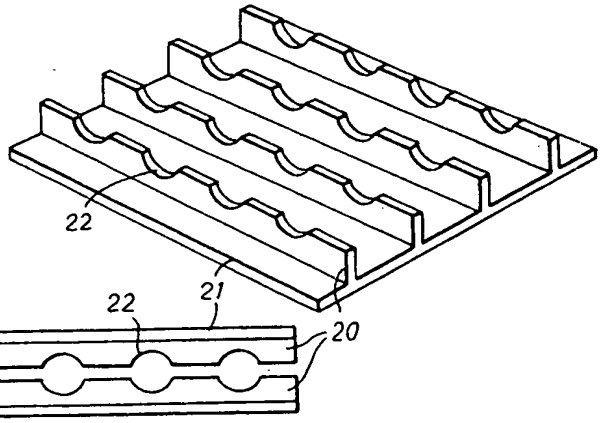


FIG. 7